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(54) **DEVICE FOR RESPIRATORY ASSISTANCE**

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(57) **ABSTRACT**

The present invention relates to a device for respiratory assistance which comprises a tube (4) having at least one auxiliary channel (8) connected to a source of respirable gas (25).

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According to the invention, in the conduit (28) connecting said source of respirable gas (25) to said auxiliary channel (8), said device includes:

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toward said source (25), a device for loss of head (30) which is able to impose on the jet of respirable gas a predetermined flow rate value and a predetermined pressure value; and

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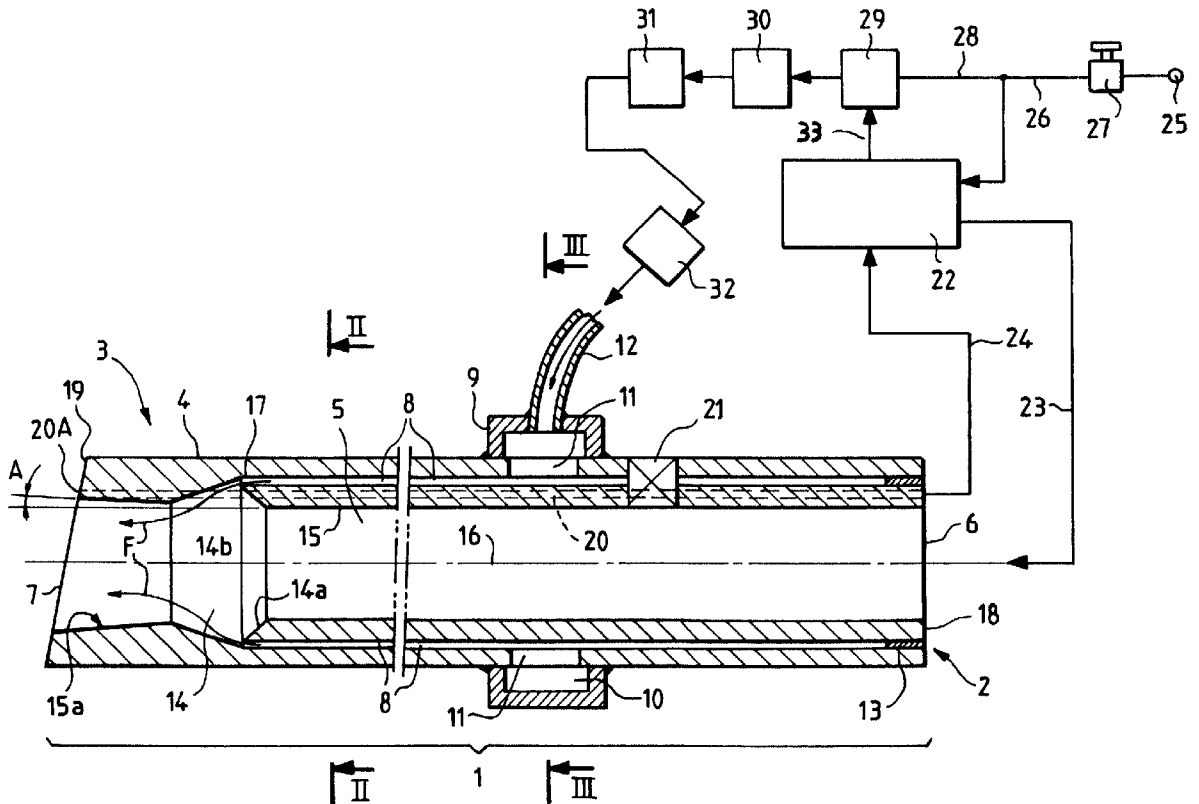
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toward said auxiliary channel (8), a calibrated exhaust valve (32) which is able to bring said conduit (28) into communication with the atmosphere when the pressure in said conduit (28) exceeds said predetermined pressure value.

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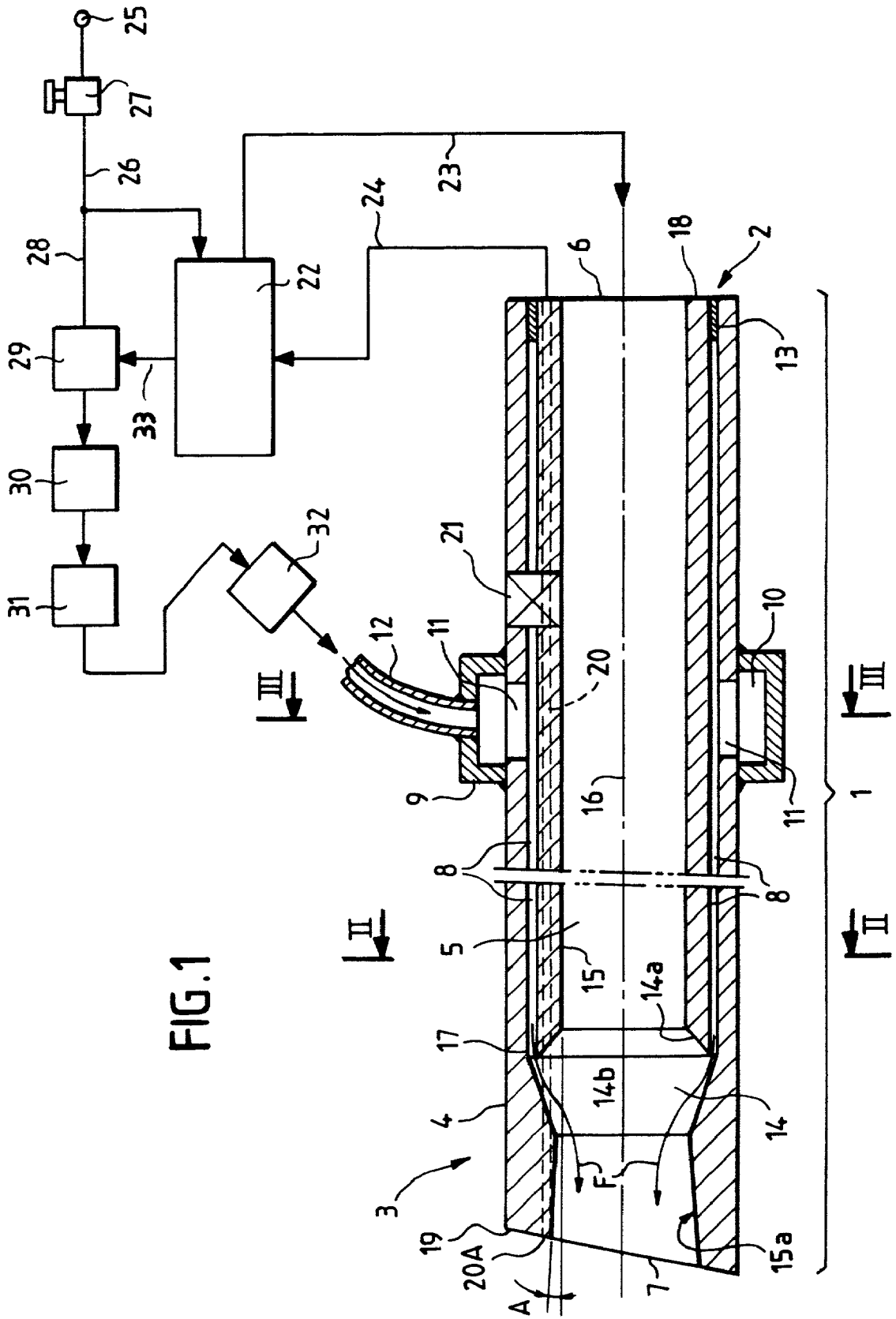


FIG. 1

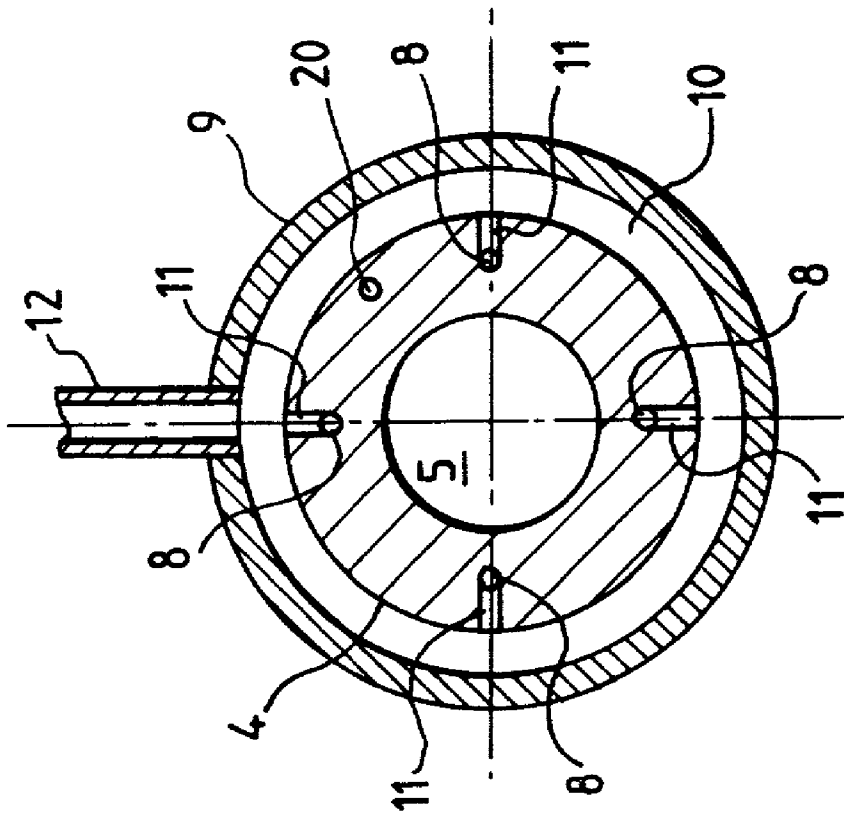


FIG. 3

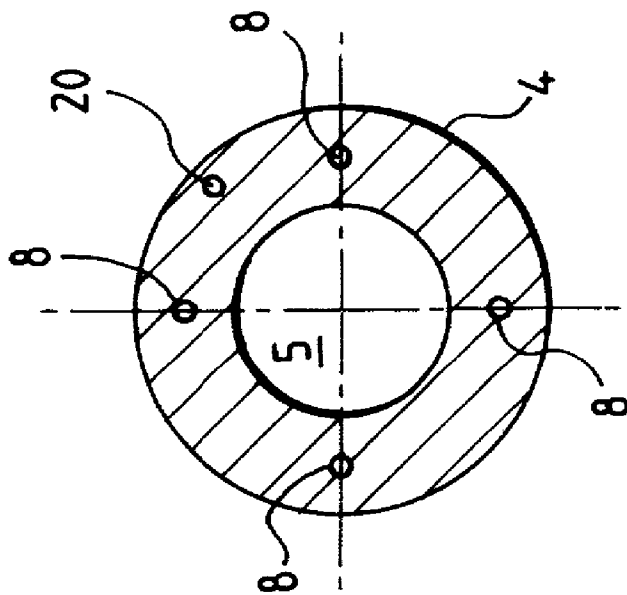


FIG. 2

### DEVICE FOR RESPIRATORY ASSISTANCE

[0001] The subject of the present invention is a device for respiratory assistance which can be used on patients in whom spontaneous respiration is absent or inadequate, whether or not said patients are placed under artificial respiration.

[0002] Various devices are known, such as masks and oral, nasal, endotracheal and tracheotomy probes or cannulas, which are intended to form the junction between an artificial respiration and/or anesthesia apparatus and the respiratory tract of a patient. These devices, essentially in the form of tubes, can, depending on the circumstances, include immobilizing means such as flanges or collars in the vicinity of the proximal end for holding them on the mouth or nose of the patient, or inflatable balloons in the vicinity of the distal end for holding them by friction in the trachea.

[0003] The known devices have important disadvantages. Thus, for example, when a tube of a known type is disconnected from the artificial respirator and the patient needs oxygen-enriched air, it is necessary to introduce into said tube a probe which is connected to an oxygen source. Moreover, in cases of inadequate spontaneous respiration, the patient must necessarily remain connected to the respirator until spontaneous respiration has been completely re-established.

[0004] To overcome these disadvantages, it has already been proposed, for example in documents EP-A-0 390 684 and EP-A-0 701 834, to provide devices for respiratory assistance which, in addition to the main channel formed by the tube, comprise at least one auxiliary channel, for example formed in the wall of said tube, permitting injection of a jet of respirable gas (oxygen, air or air/oxygen mixture) intended to ventilate the patient, this auxiliary channel opening into the main channel in the vicinity of the distal end of the latter.

[0005] Of course, these latter known devices for respiratory assistance include safety means which are able to stop the functioning of the device in the event of overpressure in the respiratory tract of the patient and/or in said tube.

[0006] The object of the present invention is to improve said devices for respiratory assistance in order to increase the safety of their use still further.

[0007] To this end, according to the invention, the device for respiratory assistance comprising a tube which forms a main channel and which is intended to be connected via its distal end to the respiratory tract of a patient so that said main channel connects the respiratory system of said patient to the outside, said device moreover comprising at least one auxiliary channel connected to a source of respirable gas so as to permit the insufflation of a jet of such a respirable gas into said respiratory system, and opening into said main channel in the vicinity of the distal end of the latter, is distinguished by the fact that, in the conduit connecting said source of respirable gas to said auxiliary channel, it includes:

[0008] toward said source, a device for loss of head which is able to limit the flow rate and the pressure of said respirable gas available at the outlet of said source, and to impose on said jet of respirable gas a predetermined flow rate value and a predetermined pressure value; and

[0009] toward said auxiliary channel, a calibrated exhaust valve which is able to bring said conduit into communication with the atmosphere when the pressure in said conduit exceeds said predetermined pressure value.

[0010] Thus, by virtue of the present invention, the safety system acts at the level of the injection of the jet of respirable gas and advantageously complements the safety systems of the known devices mentioned above which safety systems act at the level of the patient's airways.

[0011] It should be noted that in order to obtain the maximum level of safety sought by the present invention, the combination of the device for loss of head and the calibrated exhaust valve is indispensable. This is because the device for loss of head lowers the flow rate and pressure of the jet of respirable gas so that, when this pressure exceeds said predetermined value, the exhaust valve is able to evacuate the entire jet of respirable gas into the atmosphere. If said device for loss of head were to be omitted, the flow rate and the pressure of the jet of respirable gas would be able to reach values such that said jet would be able at least in part to pass through said calibrated exhaust valve in the direction of the patient's airways, instead of being evacuated into the atmosphere. This could then result in serious injury to the patient.

[0012] Such a device for loss of head can be of any known type, such as needle screw restrictions, channels of small internal diameter, etc., and the same applies to said calibrated exhaust valve, which can be of the type with plunger and pierced cylinder, with a ball or flap charged by a spring, etc.

[0013] Said device for loss of head is preferably adjustable in such a way as to make it possible to impose on said jet of respirable gas a plurality of predetermined flow rate values and pressure values. Likewise, it is advantageous for the calibration of said exhaust valve to be adjustable. Thus, it is possible to adapt the device according to the present invention to the particular case of each patient.

[0014] Especially in the case where at least part of the conduit connecting the source of respirable gas to the auxiliary channel is incorporated in said tube, the device for loss of head and/or said calibrated exhaust valve could also be incorporated in said tube. However, they are preferably external to it.

[0015] By virtue of the device for loss of head, it is particularly easy to provide a humidifier in said conduit connecting the source of respirable gas to the auxiliary channel. This is because this device for loss of head makes it possible to lower the pressure of the jet of respirable gas to a level permitting good humidification thereof. It is thereby possible to prevent the patient's mucous membrane from drying out. Said humidifier is preferably arranged between the device for loss of head and the calibrated exhaust valve.

[0016] Moreover, in order to prevent the jet of humidified respirable gas from directly hitting the mucous membrane, and the risk of its kinetic energy causing trauma to said mucous membrane, it is advantageous if, as is described in European Patent EP-A-0 390 684, at least the distal end of said auxiliary channel opening into the main channel is parallel to the latter and if there are provided, opposite the

distal orifice of said auxiliary channel, means for deflecting said jet of respirable ventilation gas toward the inside of said main channel.

[0017] Thus, the jet of humidified respirable gas, under low pressure, passing through said auxiliary channel, is deflected toward the axis of the main channel when it penetrates into the latter. Downstream of said deflection means, that is to say inside the main channel, the pressure of said jet of respirable gas falls and the jet emerges at even lower pressure via the distal orifice of the tube. Experience has shown that downstream of the distal outlet of the tube, the pressure is low and is maintained constant throughout the respiratory space. This pressure is dependent on the flow rate of respirable gas in the auxiliary channels. Consequently, with the device for respiratory assistance according to the invention, it is possible, for example, to supply humid oxygen or a humid mixture of air and oxygen directly to the lungs, at the level of the carina, and thereby to suppress the dead space which exists in the current probes and which is about one third of the total respiratory volume of adults and about half the total respiratory volume of premature babies.

[0018] The suppression of this dead space corresponds to an increase in performance of the respiratory cycle of more than 25% in all patients and of nearly 50% in certain cases.

[0019] When the device according to the invention comprises a plurality of auxiliary channels, it is advantageous for at least some of them to be supplied jointly with respirable gas. Such joint supply of said channels can be achieved by way of a distribution ring which is coaxial with said tube. Moreover, said auxiliary channels which are not jointly supplied can be used for introducing additional gaseous products such as medicinal products.

[0020] Thus, it will be seen that the device according to the invention permits, in complete safety:

[0021] humidification of the insufflated respirable gas,

[0022] long-term intubation of the respiratory assistance device without drying,

[0023] injection of medicines or anesthetics during respiratory assistance,

[0024] dynamic measurement of pressures, since it suffices to provide auxiliary channels to which appropriate probes are associated,

[0025] establishment of a microflow of respirable gas in the auxiliary channels to prevent obstruction of said channels by mucus,

[0026] an increase in the volume exchanged, since the pressure is automatically limited and there is no risk of crushing of the pulmonary capillaries,

[0027] for the same quantity of oxygen exchanged, a decrease in the amount of oxygen in the mixture, which reduces the secondary effects of the assistance,

[0028] the possibility of using respirators which are less expensive than the current respirators.

[0029] The figures in the attached drawing will show clearly how the invention can be achieved. In these figures, identical references designate like elements.

[0030] FIG. 1 is a diagrammatic and partial view, in enlarged axial section, of an embodiment of the device of the invention.

[0031] FIGS. 2 and 3 are cross sections along lines II-II and III-III, respectively, in FIG. 1.

[0032] FIG. 1 represents, diagrammatically and on a large scale, only the proximal end 2 and distal end 3 of an embodiment 1 of the device according to the invention. This embodiment can constitute, for example, an oronasal endotracheal probe with or without balloon, a pediatric endotracheal probe, a probe for gas monitoring, an endobroncheal probe, a nasopharyngeal probe, an anatomical intubation probe for children, a Cole neonatal probe, a Gedel cannula probe, a nasal probe for oxygen therapy, a nasal or buccal-nasal mask or a nasal balloon for treatment of sleep apnea.

[0033] The device 1 includes a tube 4 which is flexible or pre-shaped (to adapt to the morphology of the patient) and which delimits a main channel 5 opening out via the orifice 6 at the proximal end 2 and via the orifice 7 at the distal end 3.

[0034] Thus, the main channel 5 is capable of ensuring passage between the orifices 6 and 7, one of which (orifice 7) is intended to be located within the airways of a patient, while the other (orifice 6) is intended to be located outside said patient. This orifice 6 can open to the ambient air, and in this case the patient can inhale fresh air and exhale vitiated air through the main channel 5. As is explained below, it is also possible to connect the orifice 6 to a source of respirable gas under pressure and to provide a system of unidirectional valves, so that the patient inhales the respirable gas from said source via said main channel 5 and exhales the vitiated gas to the ambient air, again via this main channel.

[0035] The diameter of the main channel 5 is of the order of a few millimeters. Satisfactory trials have been conducted with diameters of 3 mm, 7 mm, 8 mm and 12 mm.

[0036] Moreover, auxiliary channels 8 are formed within the thickness of the wall of the tube 4, said auxiliary channels 8 extending over almost the entire length of the main channel and being intended to be connected to a source of respirable gas under pressure, as is described below.

[0037] The connection to the source of respirable gas under pressure can be effected by means of a ring 9, surrounding the tube 4 in a leaktight manner toward the proximal end 2 and delimiting a sealed annular chamber 10 around said tube. The auxiliary channels 8 are brought into communication with the chamber 10 by means of local cutouts 11 in the wall of the tube 4, and said chamber 10 is connected to said source of respirable gas via a conduit 12. Of course, the proximal ends of the channels 8 are closed, for example by stoppers 13 introduced from the proximal end face 18 of the tube 4.

[0038] The auxiliary channels 8 have a smaller diameter than that of the main channel 5. The diameter of the auxiliary channels 8 is preferably less than 1 mm and is advantageously of the order of 400 to 800 microns. At the distal end, the auxiliary channels 8 open into a recess 14 in the inner wall 15 of the tube 4. The recess 14 is annular and centered on the axis 16 of the distal end 3. It includes a face 14a which is substantially transverse or slightly inclined in such

a way as to constitute a widening of the main channel **5** into which said auxiliary channels **8** open via their orifices **17**, as well as a face **14b** following the face **14a** and converging in the direction of the axis **16**.

[0039] Preferably, between the converging inclined face **14b** and the distal orifice **7**, the inner wall **15** has a part **15a** widening slightly outward, as is illustrated by the angle A in FIG. 1.

[0040] Thus, when the auxiliary channels **8** are supplied with respirable gas under pressure by way of the elements **9** to **12**, the corresponding gaseous jets impact the inclined face **14b**, which deflects them in the direction of the axis **16** (arrows F in FIG. 1), generating in the vicinity of the latter a zone of low pressure promoting the gaseous circulation inside the main channel **5**, from the proximal orifice toward the distal orifice. This therefore favors the patient's inhalation.

[0041] The distance between each of the orifices **17** and the orifice **7** is preferably of the order of 1 to 2 cm.

[0042] At least one supplementary channel **20** is provided within the thickness of the tube **4** and opens out at **20A** in the vicinity of the distal end **19** of the tube **4** and serves as a pressure tap.

[0043] For safety reasons, a calibrated exhaust valve **21** can be provided in the proximal end **2** of the tube **4**. Thus, in the event of an accidental overpressure occurring in the main channel **5**, gas escapes to outside the patient, via the wall of the tube **4**, in order to eliminate this overpressure instantaneously.

[0044] As is shown in FIGS. 2 and 3, the auxiliary channels **8** are arranged regularly around the axis of the tube **4**. Their number is variable depending on the applications (adult or child), but is generally between three and nine. Moreover, at least one of the auxiliary channels **8** can be specialized to deliver a medical fluid.

[0045] The tube **4** of the device according to the invention can be made of any material already used in respiratory probes, for example polyvinyl chloride, with an optional coating of silicone or steel permitting high-pressure injections.

[0046] Of course, the dimensions of the device according to the invention can vary greatly, essentially depending on the mode of fitting of the tube and the size of the patient, who can be an adult, a child, an infant or a premature baby.

[0047] The device **1** moreover comprises a supply and control device **22** which is connected to the orifice **6** of the proximal end **2** of the tube **4** via a connection **23** and to the supplementary channel **20** via a connection **24**, respectively.

[0048] The supply and control device **22** is supplied with respirable gas under pressure via a source **25**, to which it is connected via a conduit **26** on which an adjustable pressure reducer/flow meter **27** is mounted.

[0049] The outlet of the pressure reducer/flow meter **27** is connected to the conduit **12** via a branch conduit **28** on which there are mounted in series a controllable valve **29**, an adjustable device for loss of head **30** for limiting flow rate and pressure, a humidifier **31** and a calibrated exhaust valve

**32** of adjustable calibration. The controllable valve **29** is controlled by the supply and control device **22** by way of a connection **33**.

[0050] By way of nonlimiting example, the pressure reducer/flow meter **27** can deliver the respirable gas coming from the source **25** into the conduit **28** at a pressure P, for example equal to 3.5 bar, with a maximum adjustable flow rate of, for example, 32 liters per minute, while the limiter of flow rate and pressure **30**, receiving this respirable gas from the conduit **28**, can lower the pressure thereof to a value p which is equal, for example, to 0.5 bar (for an adult) and 0.07 bar (for a child), and can lower the flow rate to a value d which is equal, for example, to 0.5 liter per minute. As for the exhaust valve **32**, it is calibrated to the pressure p.

[0051] The modes of functioning of the device **1** according to the invention are the following:

[0052] in the artificial respiration mode, the supply and control device **22**, on the one hand, controls the valve **29** to close by way of the connection **33**, so that the conduit **12** is not supplied with gas, and, on the other hand, conveys respirable gas into the tube **4** by way of the connection **23**. This device **22** includes means (not shown) by which it is possible to regulate the pressure and flow rate of respirable gas which it receives from the conduit **26** and which it conveys to the tube **4**. If an overpressure occurs in the respiratory tract of the patient, it is detected and transmitted, via the supplementary channel **20** and the connection **24**, to the device **22** which stops operating. Moreover, if this overpressure exceeds the calibration threshold of the calibrated valve **21**—for example because the supplementary channel **20** is obstructed by mucus and has not been able to transmit the overpressure information to the device **22**—this valve **21** opens and the proximal channel **5** is connected to the atmosphere;

[0053] in the respiratory assistance mode, the supply and control device **22** cuts off the connection **23** in order to bring the orifice **6** into communication with the atmosphere and controls the valve **29** via the connection **33** so that it conveys to the patient a continuous or pulsed jet of respirable gas by way of the limiter **30**, the humidifier **31**, the calibrated exhaust valve **32** and the auxiliary channels **8**. If an overpressure occurs in the respiratory tract of the patient, as was described above, this overpressure is detected and transmitted via the supplementary channel **20**, so that the device **22** closes the valve **29** and the conduit **28** stops conveying gas to the patient. If the supplementary channel **20** is obstructed, the device **22** is not warned of the overpressure in the respiratory tract of the patient and cannot stop, but this overpressure causes an increase in pressure in the auxiliary channels **8** and the conduit **12**. When this increase in pressure reaches the threshold for opening the safety valve **32**, the latter opens and the jet of respirable gas is no longer conveyed to the patient, but on the contrary is diverted to the outside by said safety valve **32**. Thus, although in the latter case the safety arrangement **20A**, **20**, **24**, **22**, **29** has not been able to function, the jet of respirable gas cannot reach the patient's respiratory system.

[0054] Thus, from what has been described above, it will be evident that the invention permits, with maximum safety, humidified respiratory assistance which is nonaggressive with respect to the patient, with almost complete disappearance of the dead space inherent to the known probes.

1. A device for respiratory assistance comprising a tube (4) which forms a main channel (5) and which is intended to be connected via its distal end (3) to the respiratory tract of a patient so that said main channel (5) connects the respiratory system of said patient to the outside, said device moreover comprising at least one auxiliary channel (8) connected to a source of respirable gas (25) so as to permit the insufflation of a jet of such a respirable gas into said respiratory system, and opening into said main channel (5) in the vicinity of the distal end (7) of the latter, wherein, in the conduit (28) connecting said source of respirable gas (25) to said auxiliary channel (8), said device includes:

toward said source (25), a device for loss of head (30) which is able to limit the flow rate and the pressure of said respirable gas available at the outlet of said source (25), and to impose on said jet of respirable gas a predetermined flow rate value and a predetermined pressure value; and

toward said auxiliary channel (8), a calibrated exhaust valve (32) which is able to bring said conduit (28) into communication with the atmosphere when the pressure in said conduit (28) exceeds said predetermined pressure value.

2. The device as claimed in claim 1, wherein said device for loss of head (30) is adjustable in such a way as to be able to impose on said jet of respirable gas a plurality of predetermined flow rate values and pressure values.

3. The device as claimed in claim 1, wherein the calibration of said calibrated exhaust valve (32) is adjustable.

4. The device as claimed in claim 1, wherein said device for loss of head (30) is incorporated in said tube (4).

5. The device as claimed in claim 1, wherein said device for loss of head (30) is external to said tube (4).

6. The device as claimed in claim 1, wherein said calibrated exhaust valve (32) is incorporated in said tube (4).

7. The device as claimed in claim 1, wherein said calibrated exhaust valve (32) is external to said tube (4).

8. The device as claimed in claim 1, comprising a humidifier (31) in said conduit (28) connecting the source of respirable gas (25) to said auxiliary channel (8).

9. The device as claimed in claim 8, wherein said humidifier (31) is arranged between said device for loss of head (30) and said calibrated exhaust valve (32).

10. The device as claimed in claim 1, wherein at least the distal end of said auxiliary channel (8) opening into the main channel (5) is parallel thereto, and wherein there are provided, opposite the distal orifice (17) of said auxiliary channel (8), means (14b) for deflecting said jet of respirable ventilation gas toward the inside of said main channel (5).

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